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TACTICAL OPERATIONS CENTER RESTRUCTURE CONCEPT EXPERIMENTATION PROGRAM (TOC RESTRUCTURE CEP)

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13. ABSTRACT ***(Maximum 200 Words)***
The Tactical Operations Center Restructure Concept Experimentation Program (TOC CEP) was a Concept Experimentation Program (CEP) conducted at the Mounted Warfare Test Bed (MWTB) at Ft. Knox, KY, from December 11 to December 17, 1997. The CEP was performed as Deliver Order (DO) #0060 under the Lockheed Martin advanced Distributed Simulation Technology II (ADST II) Contract administered by the U.S. Army Simulation, Training, and Instrumentation Command (STRICOM). The experiment was sponsored by two Government agencies: Training and Doctrine Command (TRADOC); and the Mounted Maneuver Battle Lab (MMBL), Ft. Knox, KY. The experiment utilized a synthetic environment that employed virtual simulations to depict a heavy Task Force executing three configurations. The scenarios in realistic combat situations in various experimental configurations. The scenarios were developed to be run on the National Training Center (NTC) terrain database, and included Attack, Defend and Movement to Contact vignettes. These scenarios were designed to produce effective operations orders and concepts, and induce the commanders and their planning staff to make tactical decisions that affected battle outcomes.

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EXECUTIVE SUMMARY

The Tactical Operations Center Restructure Concept Experimentation Program (TOC CEP) was a Concept Experimentation Program (CEP) conducted at the Mounted Warfare Test Bed (MWTB) at Fort Knox, KY, from December 11 to December 17, 1997. The CEP was performed as Delivery Order (DO) #60 under the Lockheed Martin Advanced Distributed Simulation Technology II (ADST II) Contract administered by the U.S. Army Simulation, Training, and Instrumentation Command (STRICOM). The experiment was sponsored by two Government agencies: Training and Doctrine Command (TRADOC); and the Mounted Maneuver Battle Lab (MMBL), Fort Knox, KY. The experiment utilized a synthetic environment that employed virtual simulations to depict a heavy Task Force executing three basic task force-level scenarios in realistic combat situations in various experimental configurations. The scenarios were developed to be run on the National Training Center (NTC) terrain database, and included Attack, Defend and Movement to Contact vignettes. These scenarios were designed to produce effective operations orders and concepts, and induce the commanders and their planning staff to make tactical decisions that affected battle outcomes. The objectives of the effort were:

1) Provide insights into the information requirements of a Battalion Commander's decision making process given near perfect Situation Awareness (SA).

2) Provide insights into the implementation of information displays for the Commander and TOC elements of the heavy Battalion Task Force TOC.

3) Provide insights into the training, doctrine, personnel, and functional changes to TOC operations based on a future digitized TOC using the Command and Control Vehicle (C2V) platform and projected information system capabilities.

Development of the software modifications to Modular Semi-Automated Forces (ModSAF) and the initial integration of software models were conducted at both the Operational Support Facility (OSF) in Orlando, FL and the MWTB. The final integration phase was completed at the MWTB from November 15 to December 1, 1997.

The experiment's test trial window was five (5) days. This five-day period included four (4) days to execute the trial run matrix and an additional day for excursion runs. The trial run matrix was executed within the allocated time and the fifth day was used for excursion runs as scheduled.

In accordance with the Government SOW, this Final Report includes a description of the experiment, its conditions and conduct, and lessons learned. This report addresses the interconnectivity of simulation systems, modifications to both ModSAF and the manned simulators, and the integration of Government Furnished software models. This report does not include discussion of data analysis nor conclusions as to whether the customer(s) achieved their objectives of the experiment.

1. INTRODUCTION

1.1 Purpose

The purpose of this final report is to document the ADST II effort that supported TOC CEP. This report includes a full description of the experiment, its architectural design, its conditions, and lessons learned.

1.2 Contract Overview

TOC CEP was performed, as DO #0060 under the Lockheed Martin Corporation (LMC) ADST II contract with STRICOM. The contract, a Unilateral Delivery Order, required LMC to analyze the technical and experimental architecture of the experiment, provide support in the development of training and test scenarios, configure and integrate the MWTB and TBV2B assets for the experiment, and assist in data reduction.

1.3 Experiment Overview.

The purpose of TOC CEP was to use man-in-the loop simulators, vehicle mockups, and simulated forces to evaluate the effect of combining situational awareness and the implementation of new information displays into a Task Force TOC in order to provide insights into the training, doctrine, and personnel changes to TOC operations using the C2V projected platform capabilities. The experiment employed three manned C2V mockups (two configured as a Task Force Level TOC, and one configured as a Brigade node to a TOC), and one Advanced Research Projects Agency (ARPA) Reconfigurable Simulator Initiative (ARSI) Simulator (configured as a Bradley Fighting Vehicle and used as the Task Force Commander's C2V).

The mockups and simulator were augmented with role players and ModSAF to depict a heavy Task Force that conducted tactical operations against a doctrinally approved and depicted Opposing Force (OPFOR) ModSAF threat.

1.4 Technical Overview

The technical approach to the TOC CEP involved the analysis of the technical and experimental architecture of the experiment, development of software, and the configuration and integration the MWTB and TBV2B assets into the experiment configuration.

Software development was conducted primarily on-site at the MWTB, with additional work conducted at the Operational Support Facility (OSF). Development of the software was conducted in a "rapid prototyping" or "spiral development" manner, with multiple "code, test, fix/change" iterations in order to meet the customer's requirements. Once the synthetic environment functional tests were completed, Fort Knox conducted troop training and a Pilot Test. After the Pilot Test was completed, the configuration was frozen and approval obtained to start the experiment. The actual experiment period lasted five (5) days. Four days were used to complete the matrix and the last day was used for an excursion run.

2. Applicable Documents

2.1 Government

-ADST II Work Statement for Tactical Operations Center Restructure Concept Experimentation Program (TOC Restructure CEP), September 8, 1997, AMSTI-97-WO89

-Battle Lab Experiment Plan (BLEP) for TOC Restructure CEP, ATZK-MW, Fort Knox, KY, November 21, 1997

2.2 Non-Government

3. System Description

3.1 System Configuration and Layout

The MWTB contains a variety of simulators, networks, ModSAF capabilities, displays for monitoring the battlefield, utilities to facilitate exercises, and automated data collection and reduction capabilities. The platforms used for TOC CEP are depicted in Figure 1.

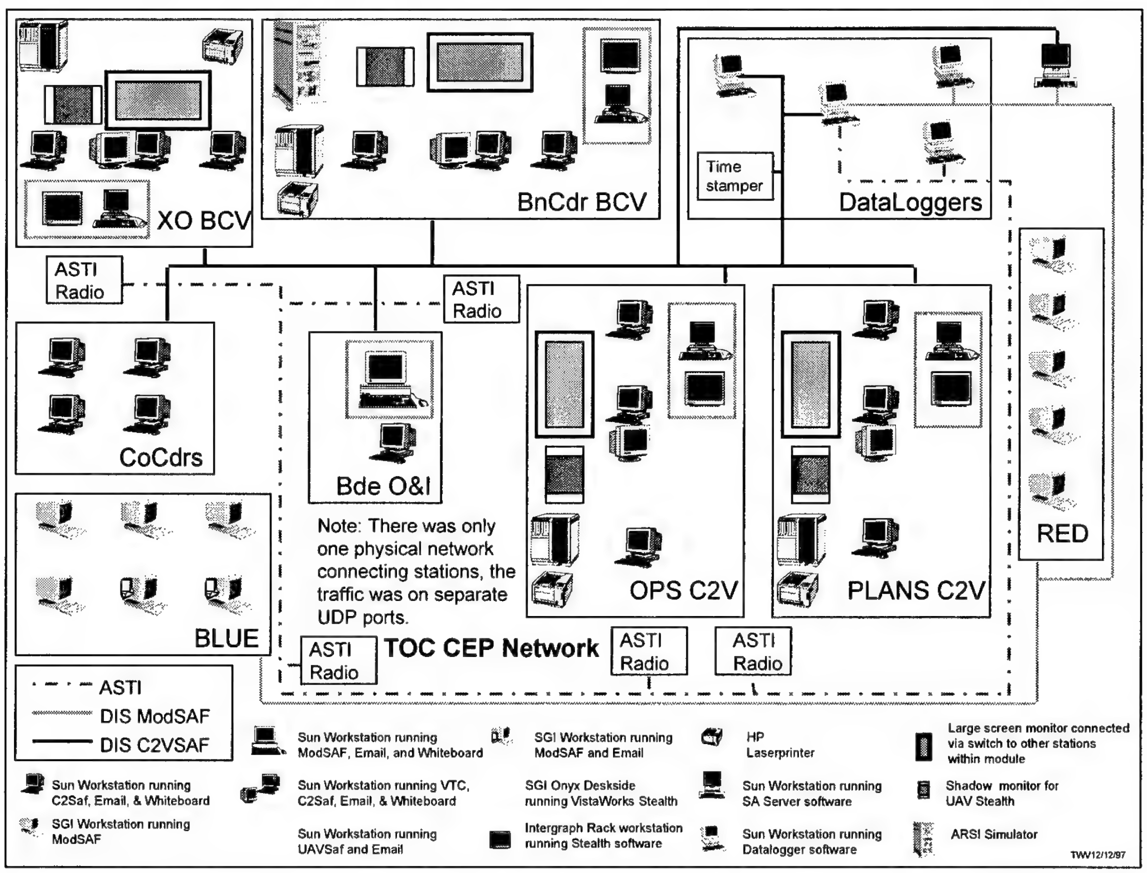


Figure 1 TOC CEP Asset and Network Layout at MWTB

The experiment was conducted using assets interconnected on Ethernet LANs via twisted pair cable. Simulation assets used Distributed Interactive Simulation (DIS) 2.03 protocol. Table 1 lists assets used at the MWTB/TB2VB.

ADST II ASSET	PURPOSE	PROTOCOL
Command and Control Vehicle (C2V) Mockup	Task Force and Brigade Tactical Command Post	DIS 2.03
Stealth	Battlefield Visualization Display for Company Commander Role-player	DIS 2.03
ModSAF Workstations	Semi-Automated Forces for BLUFOR and OPFOR	DIS 2.03
ASTi Radio Simulator	Simulated Radio Communications	DIS 2.03
Plan View Display	Terrain Map of the battlefield for Exercise Control (simulated C2 display)	DIS 2.03
Data Loggers	Record of DIS PDUs for Data Collection & Analysis	DIS 2.03
DIS Time Stamper	Time Stamp of DIS PDUs for Data Collection & Analysis	DIS 2.03

Table 1 ADST II MWTB/TB2VB Assets

In addition to the manned simulators and assets listed in Table 1 above, there were nine SGI workstations, twenty-two Sun workstations, and two SUN Ultras required to support the CEP. Figure 2 depicts the TOC CEP Hardware Assets Diagram to support the experiment.

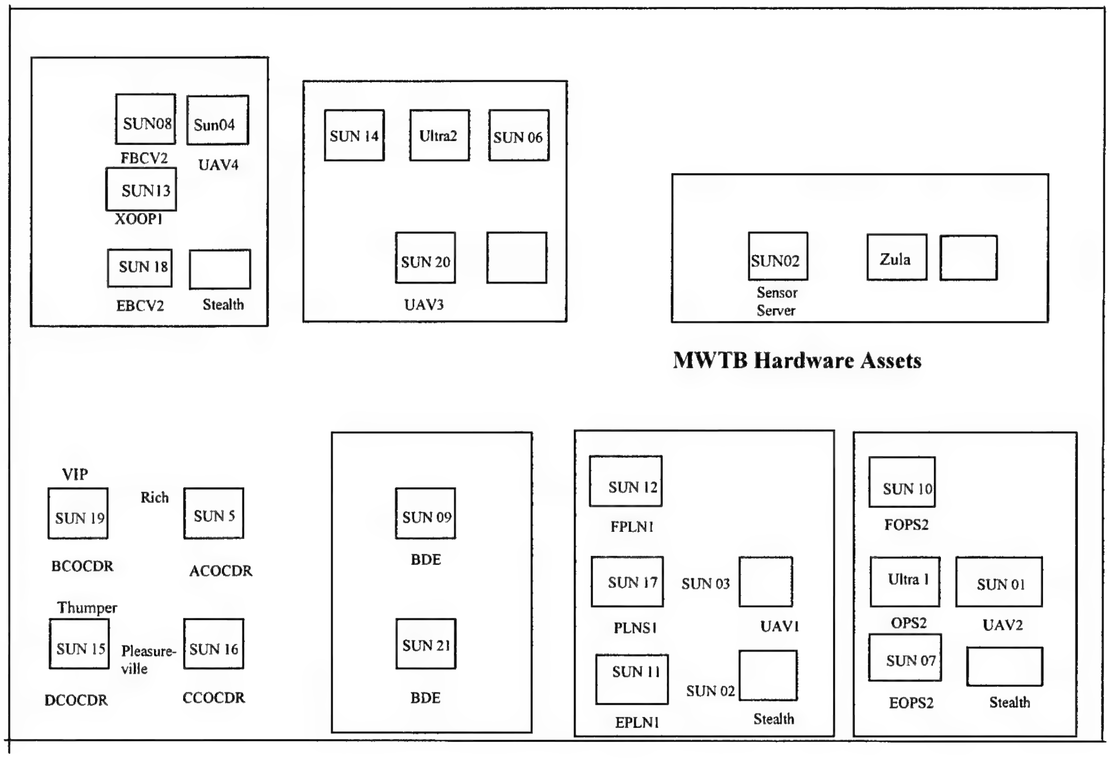


Figure 2 TOC CEP Hardware Assets Diagram

A detailed diagram of the floor plan and block diagram used for the experiment are shown as figures 6 and 7 in Appendix A, page 1-2.

3.2 Description of System Components

This section discusses the description, functionality and operation of the system components, which includes the Government Furnished Equipment (GFE) models and their integration with the hardware at the MWTB. Figure 3 shows the Communications Network Diagram.

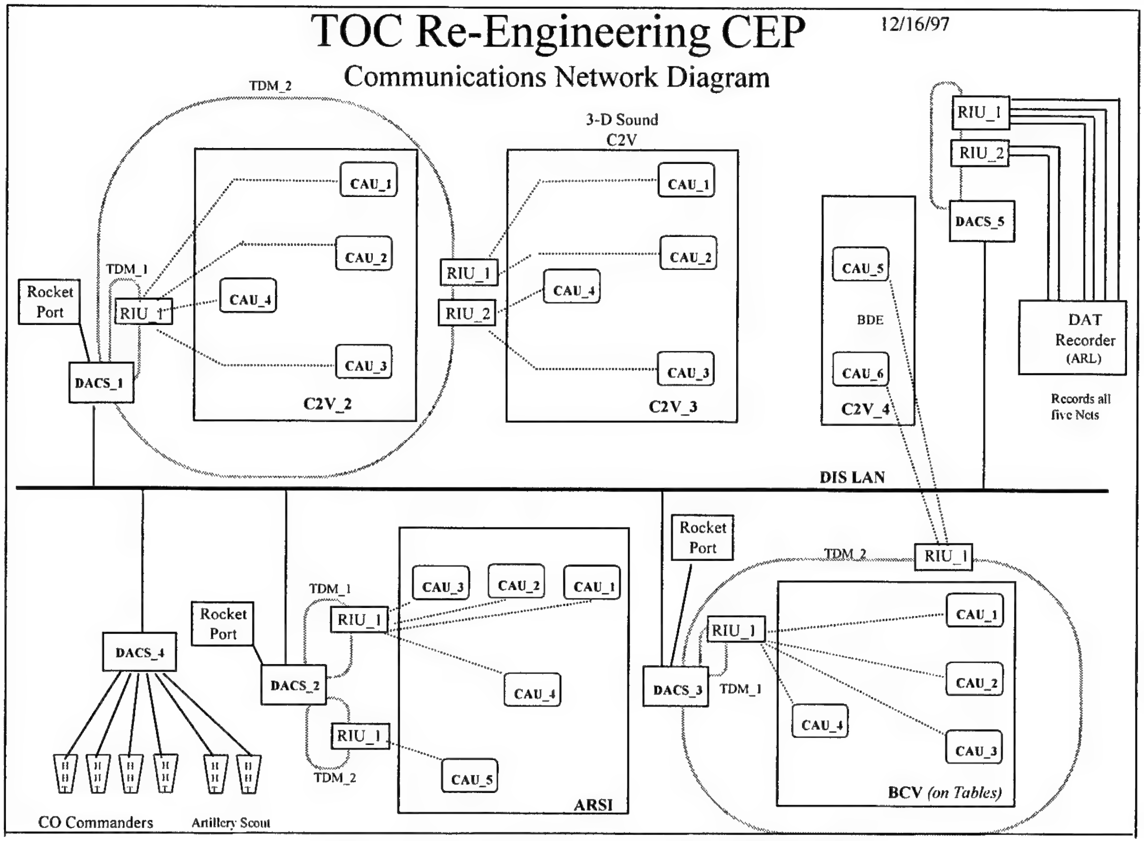


Figure 3 Communications Network Diagram

The Communications Network and DIS Radio Network Settings are shown as figures 8 and 9 in Appendix A, page 3-4.

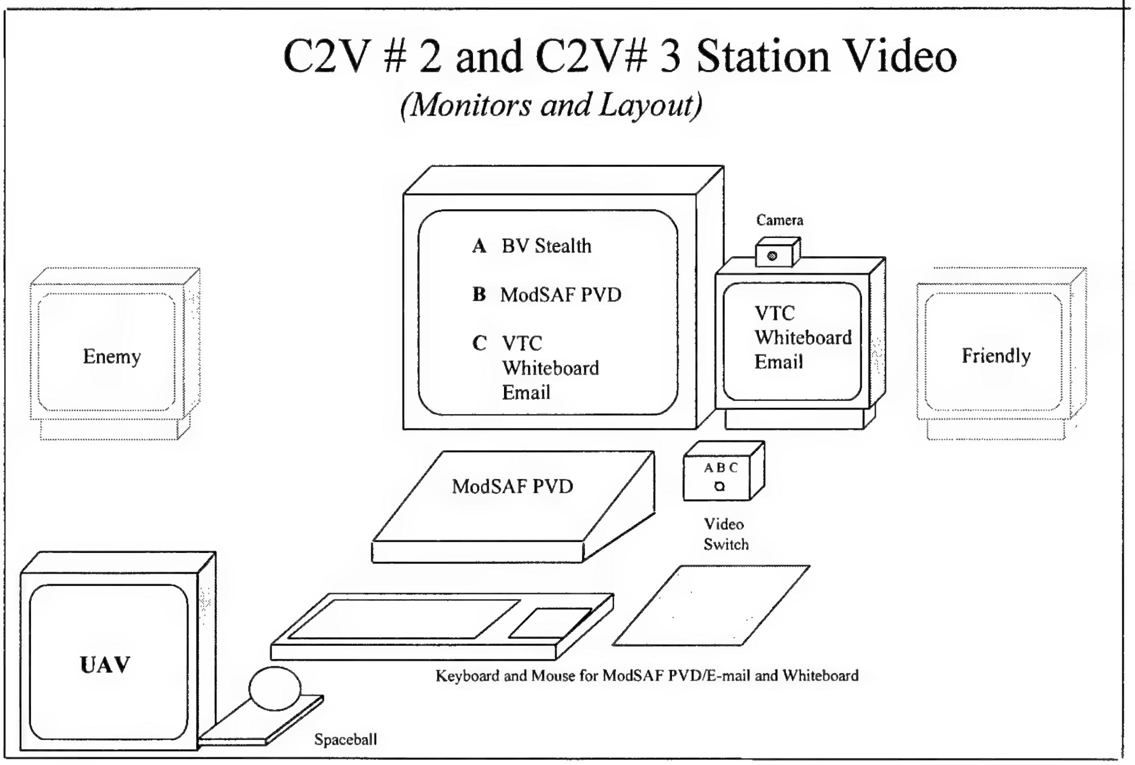
3.2.1 Command and Control Vehicle #2/Command and Control Vehicle #3

The C2V mockup replicates a Command and Control Vehicle for various echelons of command and is configured on a Multiple Launch Rocket System (MLRS) chassis. Both the C2V #2 & C2V #3 vehicles were configured in a similar fashion (C2V #1 was not used). However, C2V #3 was equipped with helmet mounted displays for the operators. The purpose of the heads-up displays was to see if they provided any increase in efficiency to the operators in comparison to those in the other C2V that did not have them.

C2V #2 and C2V #3 replicated a Battalion Task Force TOC. Each of these vehicles had an officer in charge (OIC) positioned in the center of the vehicle in front of a simulated flat panel display (large screen monitor). Two additional operations officers flanked the OIC. The officer on the right monitored the friendly operations and the officer on the left monitored the enemy operations. Another officer was positioned to the rear of the OIC and monitored and controlled an Unmanned Aerial Vehicle (UAV). A video feed of the UAV view was also provided to the commander.

The purpose of the two C2Vs was to have one control and monitor the current tactical operation and the other start the planning for future operations. When the current operation was complete and the planning for the follow-on operation was complete, a transition

between the two vehicles allowed for the second C2V to start the control for the next operation which it had planned and the original C2V which completed the operational control of the previous mission would revert to planning the next operation. These two vehicles would continue to alternate between the controlling of the current operation to the planning for the future operation.



VIDEOB1.PPT

Figure 4 C2V #2 and C2V #3 Station Video

Detailed diagrams of C2V wiring, headset and headphone configurations are shown as figures 10 through 17 in Appendix A, page 5-12.

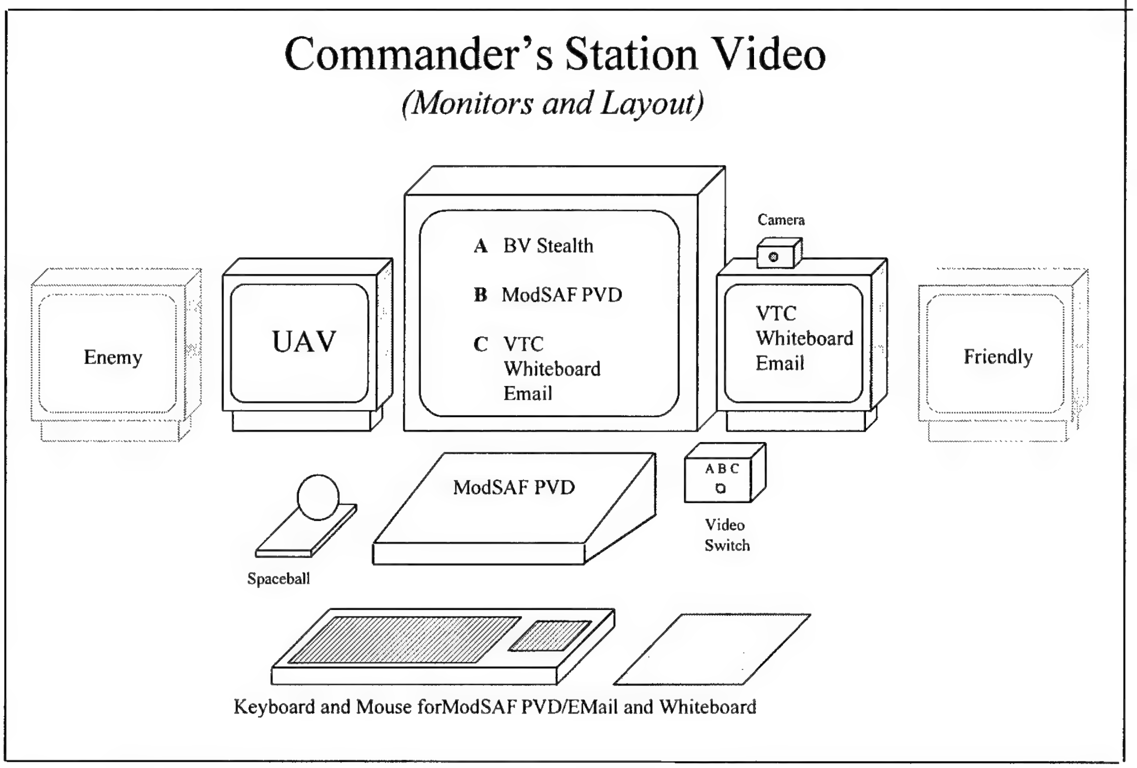
3.2.2 Command and control Vehicle #4

C2V #4 was configured as the Brigade node. This was the next higher echelon of command and provided guidance and control for the other elements in the experiment. This vehicle was manned with the Brigade Commander and two Brigade Operations Officers. Each operations officer worked and manned a C2V SAF station.

3.2.3 ARPA Reconfigurable Simulator Initiative (ARSI) Simulator

The ARSI Simulator was configured to replicate the Task Force Commander's Bradley Fighting Vehicle (BFV) who was used for command and control of the Task Force. This vehicle was configured with a driver in the hull and with a crew of three in the crew compartment and turret. The commander is centered in the center in front of a simulated flat panel display, and is flanked on both sides with two operations officers that provide the same functionality as the crew of the C2V. From this simulator the Task Force Commander

analyzed information provided by the C2Vs and directed the four company commanders in his task force. The commander's station video monitoring capability is depicted in Figure 5.



VIDEOBI.PPT

Figure 5 Commander's Station Video

3.2.4 Company Commander's Stations

Four company commanders participated in the exercise. These commanders operated C2 SUN workstations and their subordinate platoons were replicated in ModSAF on SGI Indy workstations. The Company Commander's Video Distribution is shown as figure 18 in Appendix A page 13.

3.2.5 Artillery Station

Artillery was played from a ModSAF SGI workstation.

3.2.6 Scout Station

Scout and reconnaissance functions were played from a ModSAF SGI workstation.

3.2.7 C2V SAF

Due to the future timeframe of the technologies being examined for TOC CEP, use of the current generation C2 systems in the experiment would not suffice. Therefore, a simulated "next generation C2 system was created through the use of ModSAF code. The ModSAF Plan View Display (PVD) was altered and enhanced to serve as the display system of this notional C2 system. Additional reporting capabilities, menus, operations, etc. were added to simulate a complete C2 display system. This experimental system, referred to as "C2V

SAF," was used to examine the optimum information presentation/mix to the Commanders. (The reader is cautioned to note that C2V SAF is not a SAF system which plays C2 messaging and functionality, but rather is an implementation/reuse of ModSAF code in order to simulate a C2 system.)

3.2.8 Sensor Server

The sensor server was a SUN Sparc 20 workstation. It was running modified ModSAF 3.0 software that would receive DIS 2.03 data packets on User Datagram Protocol (UDP) port 3000 (real world) and pass them to UDP port 3010 (sensed world) if they were friendly entities or enemy entities that had been sensed by blue intelligence. Real world and sensed world used the same physical network.

3.2.9 ModSAF Operations

ModSAF was connected to Network Port 3000, and C2V SAF was connected to Network Port 3010. These diagrams are shown as figures 19-20 in Appendix A, page 14-15.

3.2.10 Data Logger

The Data Logger is an ADST II asset that captures the network traffic and places the data packets on a disk or tape file. The Data Logger performs the following functions:

a. Packet Recording - Receives packets from the DIS network time stamps and then writes to a disk or tape.
b. Packet Playback - Packets from a recorded exercise can be transmitted in real time or faster than real time. The Data Logger can also suspend playback (freeze time) and skip backward or forward to a designated point in time. The logger can be controlled directly from the keyboard or remotely from the Plan View Display (PVD). Playback is visible to any device on the network (PVD, Stealth Vehicle, a vehicle simulator, etc.).
c. Copying or Converting - Files are copied to another file, which can be on the same or a different medium; and files from the older version of the Data Logger can be converted to a format compatible with the current version of the Data Logger.

For TOC CEP, two data loggers were employed to capture the exercise. The two data loggers were placed on the DIS net to capture all DIS PDUs for analysis. These two loggers used Sun IPX systems with 48 MB RAM, 1 GB Hard drive, utilizing the Sun OS 4.1.3 operating system. One data logger was designated as a back up and was not needed.

3.2.11 Time Stamper

The MWTB provided a Time Stamper that consisted of a video time code generator; an IBM-compatible Personal Computer (PC) loaded with the MS-DOS operating system, as well as a coaxial cable connecting the two units. This time code generator produced time data in days, and since 1 January, in hour/min/sec/1/1000 second in IRIG B format. The PC runs a program that reads the IRIG B time signals and converts them into time data to be sent out as a DIS 2.03 time stamp PDU once a minute. The DIS Logger receives the time stamp in PDUs and adjusts its internal clock accordingly. The DIS PDUs on the simulation network are then tagged with this time as they are sequentially received by the DIS Logger.

3.2.12 C2 Stealth System

ADST II Stealths were used to simulate a notional battlefield visualization tool. The Stealth permits the controller to fly around the virtual battlefield and view the simulation without interfering with the action. The features of the Stealth allow the observer to survey the virtual battlefield from a variety of different perspectives. The intent of the Stealths located in the C2Vs for TOC CEP was to provide the commanders with a virtual representation of the battlefield. This notional system would use a Synthetic Natural Environment (SNE) terrain database of the actual battlefield area, and would populate it with entities (vehicles, etc.) based on data from the real world. The real world systems supplying this data would include items such as: locations of friendly forces via SA messages (from blue C2 devices); locations of enemy forces based on reports from blue C2 devices; locations of enemy forces based on data from friendly sensing platforms (i.e, UAVs, etc); and others. This notional visualization system was simulated by connecting a Stealth to the "sensed" network, thereby allowing the stealth to function as normal, with no modifications, yet only display what the Sensor Server had decided was "sensed" in the battlefield.

Four vehicles were equipped with C2 Stealths; the BCV (ARSI, BCV (table setup), C2V #2 and C2V #3. Their military functions were BN BCV, XO (Deputy CMDR's) BCV, BN OPS and BN PLANS.

A SGI Deskside ONYX running the VistaWorks 3D software was used as a platform for the C2 Stealth. The C2 Stealth's network interface was configured for the sensed world. The 3D image was viewed on a 37 inch (640 x 480) Mitsubishi Monitor at the commander' station. The monitor was positioned so that its backend protruded through the C2V's wall, in order to more realistically simulate a flat panel display's space claim. A SGI Spaceball (attached to the Deskside ONYX) was placed on the commander's desk, allowing him to search the virtual battlefield in free fly mode, assess battle situations and plan actions.

3.2.13 DIS LAN Network Configuration

A DIS LAN configuration was used with 10 BaseT standard cable. Additionally, a Sun Sparc Station was configured to enable the MWTB to FTP and have access to the Orlando corporate and simulation network. During software integration, a connection was established from the DIS LAN to the Orlando OSF to allow FTP as well as the ability to log in and work on systems from the OSF.

3.3 Database and Scenario Development

The existing ADST II National Training Center (NTC) terrain database was used to support the experiment. Three test scenarios and two training scenarios were developed to support TOC CEP. Scenarios depicted a Task Force conducting a Deliberate Attack, Defense, and Movement to Contact operations. The scenarios included Operations Orders (OPORD), Fragmentary Orders (FRAGOs) and overlays to support the mission. The Mounted Maneuver Battle Lab and ADST II Lockheed Martin Services Group (LMSG) MWTB personnel developed the orders and overlays.

4. Conduct of The Experiment

4.1 Troop Training

In order to get the maximum benefit from the Pilot Test, a week was set aside for troop training to bring the soldiers up to a level of confidence on the systems prior to the Pilot Test. This troop training was conducted at the MWTB from December 1 to December 8, 1997. MWTB personnel provided classroom and hands-on training consisting of familiarization and orientation on the actual simulation systems and vehicle mockups.

4.2 Pilot Test

The Pilot Test was conducted at the MWTB on December 9-10. During this week, the soldiers used the skills acquired in troop training to conduct tactical operations in a scenario specially designed to stress the systems and the soldier's skills.

4.3 Experiment and Trial Runs

The trial runs for the experiment began on December 11 and ended on December 17, 1997. A total of four trial runs were conducted and one excursion run was conducted. The experimental unit was a Task Force.

5. Observations and Lessons Learned

- **Observation #1**

As an attempt to save cost, LMC decided to reallocate funding and not have a Project Director, even though STRICOM repeatedly advised that one was needed and requested that one be assigned.

Discussion #1

During the initial start up portion of the DO, it was determined by LMC that, in order to save cost, this effort would only have a Lead Engineer and no Project Director. Due to the complexity of the experiment and the need for extensive coordination and engineering tasks to be completed, the initial phases of the effort were slow in getting started, and the requirements were not understood by the IPT. This resulted in late arrival of software, confusion in the ordering of hardware and an extremely poor start from the inception of the effort and up to the MWTB integration phase. During the MWTB integration phase, LMC agreed with the Government that a Project Director was indeed needed to control the effort. With the addition of a Project Director and another strong engineer, the project was turned around and ended up being completed on time with customer satisfaction.

- **Lesson Learned #1**

All efforts need a Project Director, even if only on a part time basis, to control the effort while the engineers complete the technical requirements.

- **Observation #2**

Customer requirements were not clearly understood at the start of the effort.

- **Discussion #2**

The initial customer requirements were not clearly defined at the start of the effort and time was lost attempting to understand the scope of the effort. The reason for this confusion was due to a lack of definition by the customer due to the "rapid prototyping" nature of the development,and a lack of coordination within the IPT in order to understand the requirements as they developed. The IPT process was initially not expecting, and therefore not geared towards, a rapid prototyping development approach. This resulted in the IPT initially not being very effective on the DO. Later on in development, the IPT adapted to the rapid prototyping nature, and began to better track, manage, and meet requirements.

- **Lesson Learned #2**

The IPT process must be in place, clearly defined, and participated in an active manner throughout the process to completely understand, define and accomplish the goals set forth by the customer. Rapid prototyping DOs such as these, which by their nature include only partially defined requirements, require careful analysis and planning from the onset to ensure resources can be adapted or modified as needed as the development progresses and evolves.

6. Conclusion

The TOC Restructure CEP experiment accomplished it's primary goal which was to evaluate a concept which would redefine future hardware and personnel requirements to enhance the decision making capability for the Commander and his staff in the Task Force TOC of the future. The success of this initial effort has resulted in the approval and expansion for additional evaluations to further redefine these requirements. Currently two more experiments are scheduled in the next twelve months. These future experiments are currently the number one priority of the Fort Knox Battle Lab.

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Acronym List

AAR	After Action Review
ADST	Advanced Distributed Simulation Technology
ARPA	Advanced Research Projects Agency
ARSI	ARPA Reconfigurable Simulator Initiative
BFV	Bradley Fighting Vehicle
BLEP	Battle Lab Experiment Plan
BLUFOR	Blue Forces
C2	Command and Control
C2V	Command and Control Vehicle
CDRL	Contract Data Requirements List
CEP	Concept Evaluation Program
DO	Delivery Order
DIS	Distributed Interactive Simulation
FRAGO	Fragmentary Order
FTP	File Transfer Protocol
GFE	Government Furnished Equipment
H/W	Hardware
IPT	Integrated Product Team
LAN	Local Area Network
LMC	Lockheed Martin Corporation
LMSG	Lockheed Martin Service Group
ModSAF	Modular Semi-Automated Forces
MMBL	Mounted Maneuver Battle Lab
MWTB	Mounted Warfare Test Bed
NTC	National Training Center
OC	Observer Controller
OIC	Officer in Charge
OPFOR	Opposing Forces

OPORD	Operations Order
OS	Operating System
OSF	Operational Support Facility
PC	Personnel Computer
PDU	Protocol Data Unit
POC	Point of Contact
PVD	Plan View Display
RIU	Radio Interface Unit
SA	Situational Awareness
SAF	Semi-Automated Forces
SGI	Silicon Graphics Industries
SOW	Statement of Work
STRICOM	(US Army) Simulation Training and Instrumentation Command
TB2VB	TRADOC Brigade and Below Virtual Battlefield
TF	Task Force
TOC	Tactical Operations Center
TRADOC	Training and Doctrine Command
TTP	Tactics, Techniques, and Procedures
UAV	Unmanned Aerial Vehicle
UDP	User Datagram Protocol

Appendix A – Additional Drawings and Tables

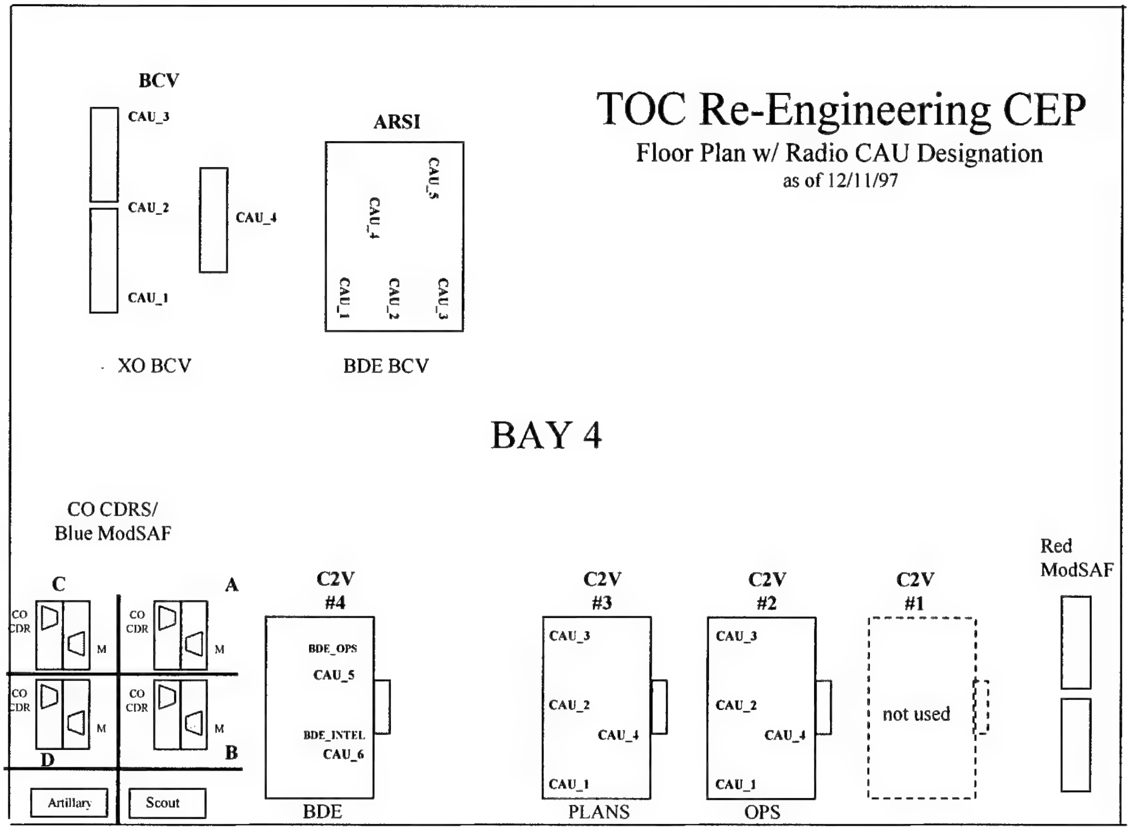

Figure 6 TOC Re-Engineering CEP Floor Plan with Radio CAU Designation

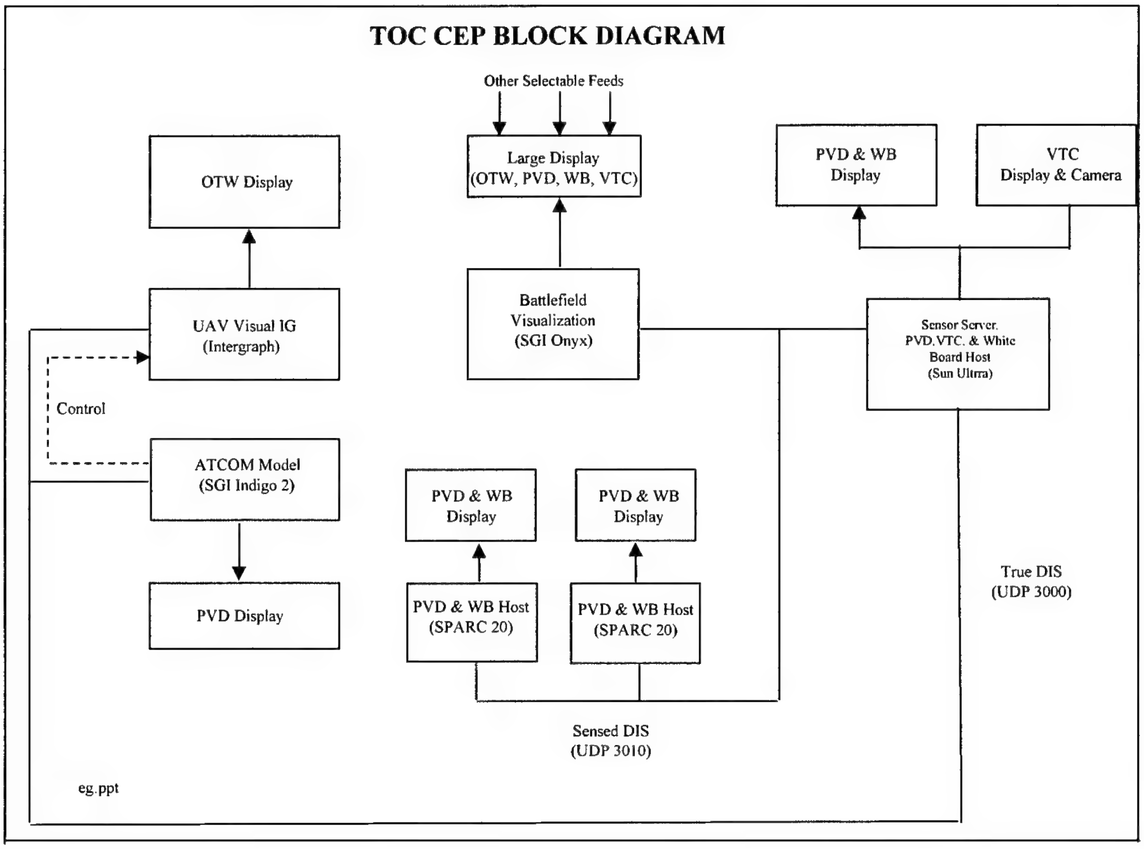

Figure 7 TOC CEP Block Diagram

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TOC Re-Engineering CEP

Communication Nets

Radio Channels	Nets	C2V_2	C2V_3	BCV	ARSI	Co_Cdrs	BDE
Channel_1	Bde Cmd	x	x	x	x		
Channel_2	Bde O/I	x	x	x	x		x
Channel_3	Bn Cmd	x	x	x	x	x	x
Channel_4	Bn O/I	x	x	x	x	x	x
Channel_5	FSN	x	x	x	x		x
Intercom Ch_1	Intercom	x	x	x	x		

Intercom Channel 1 between vehicles is enabled whenever two vehicles are within 120 meters. Crewmen within the same vehicle have intra-com on CAU Intercom Channel 1.

Figure 8 TOC Re-Engineering CEP Communication Nets

TOC Re-Engineering CEP

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DIS Radio Network Settings

DACS#	Ref_Des	Model#	Site_ID	Host_ID	Entity_ID	DIS_ID	Default_Pos	IP-Address	UDP_Port
1	C2V_2	1	3	10	1	3:18:01	0	166.30.31.150	6994
	C2V_3	2	3	10	2	3:18:01	150		
2	ARSI	1	3	20	1	3:02:01	300	166.30.31.151	6994
	ARSI	2	3	20	2	3:02:01	300		
3	BCV	1	3	30	1	3:19:01	450	166.30.31.152	6994
	C2V_4	2	3	30	2	3:19:01	600		
4	CO_CDRS	1	3	40	1	3:04:01	0	166.30.31.153	6994
5	ARL	1	3	60	1	3:15:01	0	166.30.31.155	6994

In this experiment the ASTi radios are set up for clear communications

Figure 9 DIS Radio Network Settings

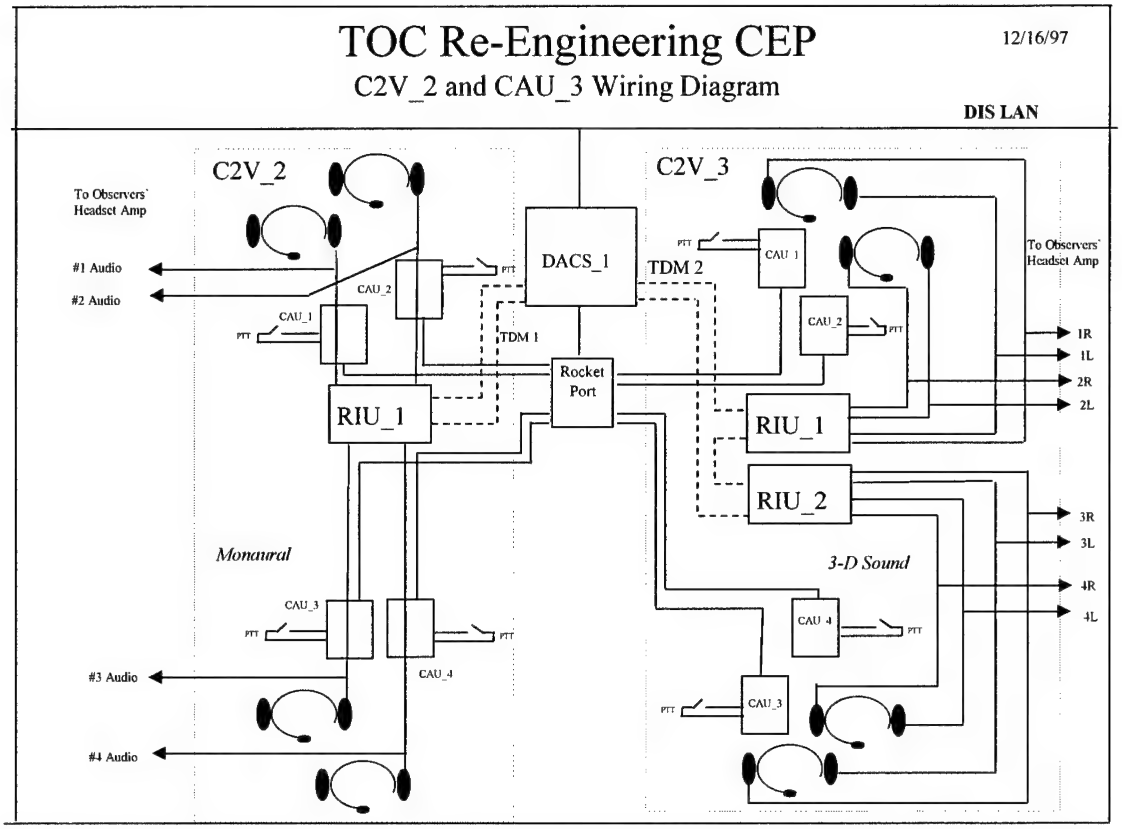


Figure 10 TOC Re-Engineering CEP C2V #2 and CAU #3 Wiring Diagrams

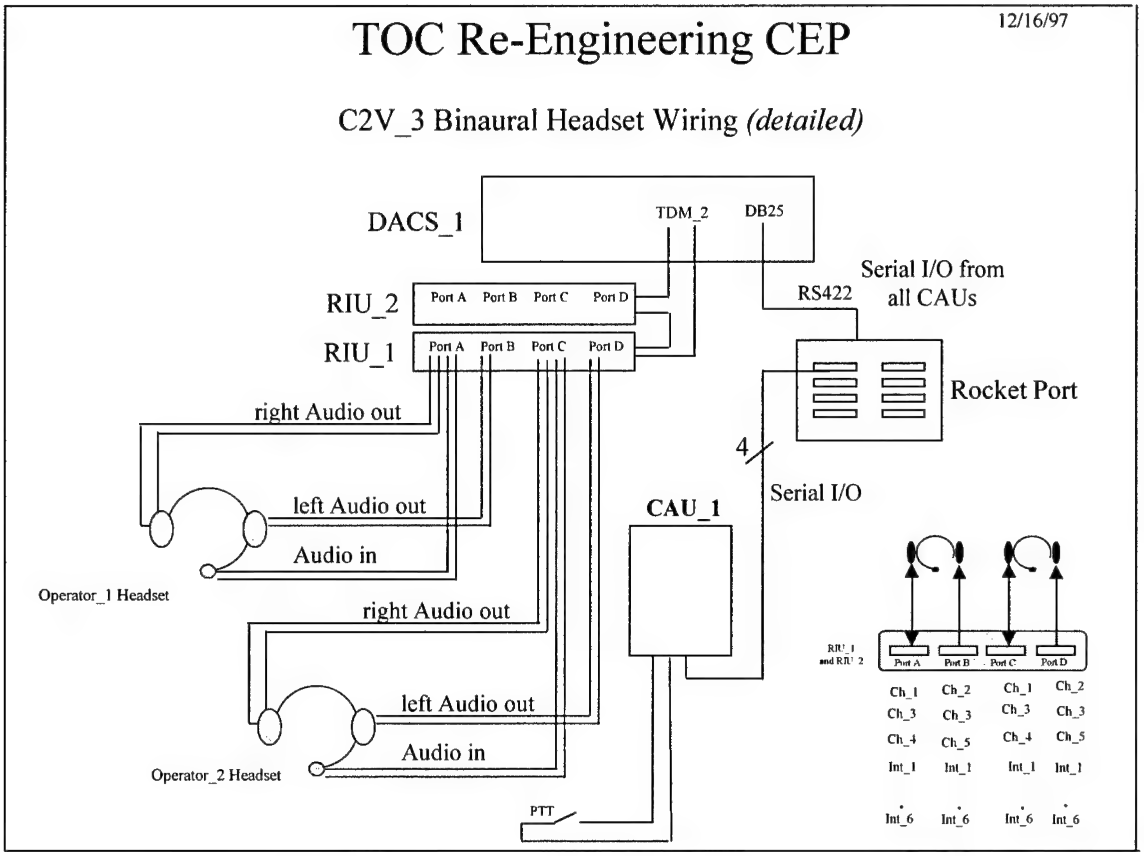


Figure 11 TOC Re-Engineering CEP C2V #3 Binaural Headset Wiring

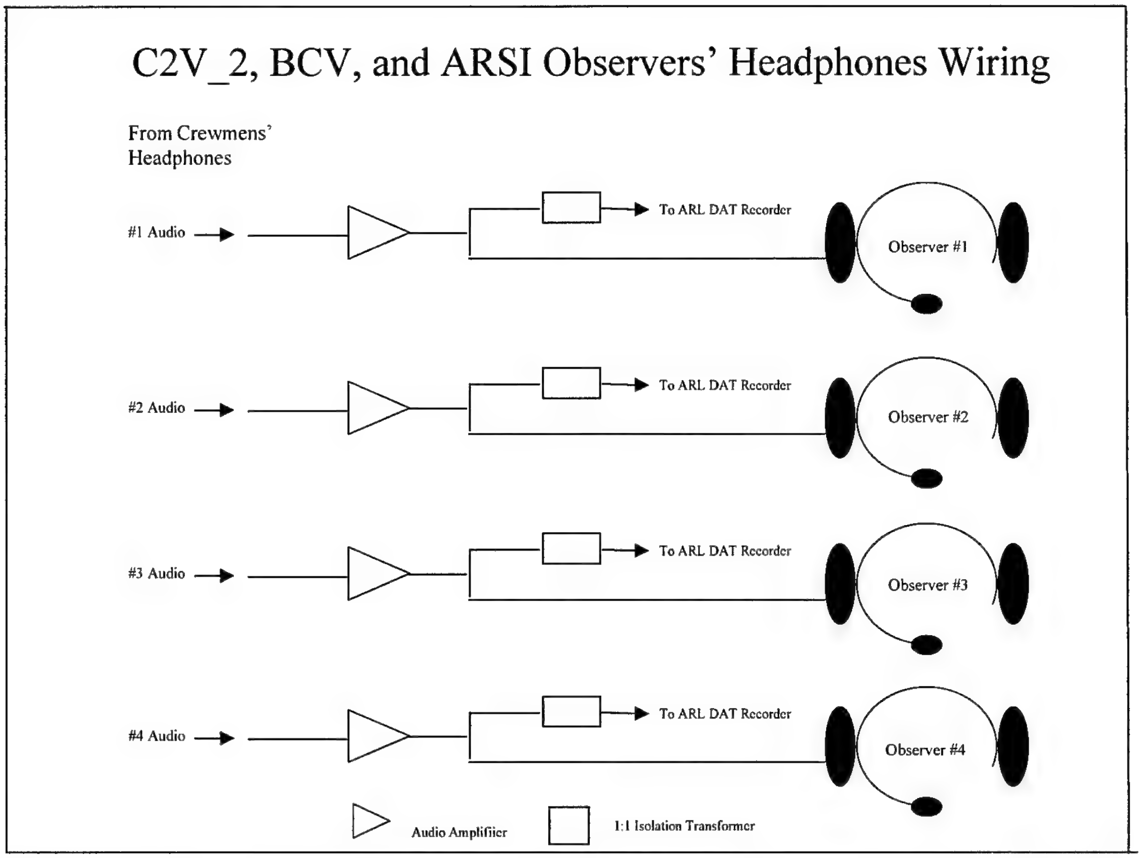
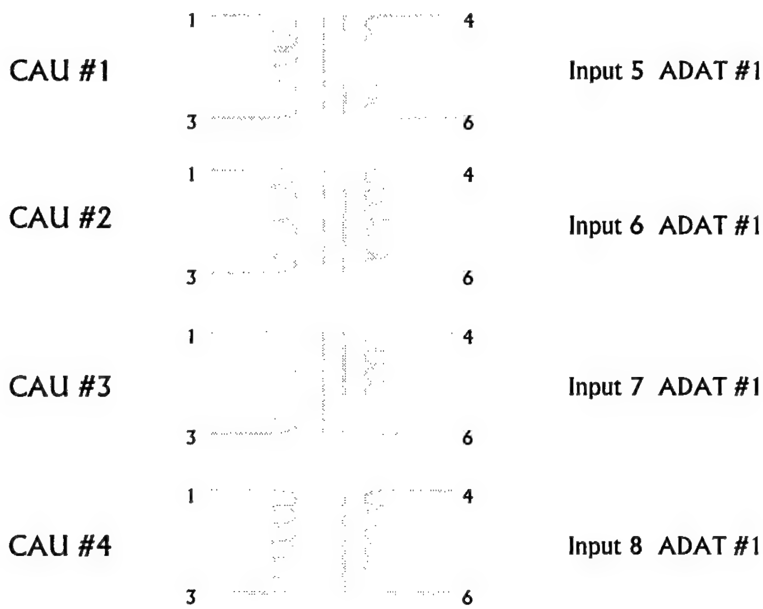


Figure 12 C2V, BCV, and ARSI Observers' Headphones Wiring

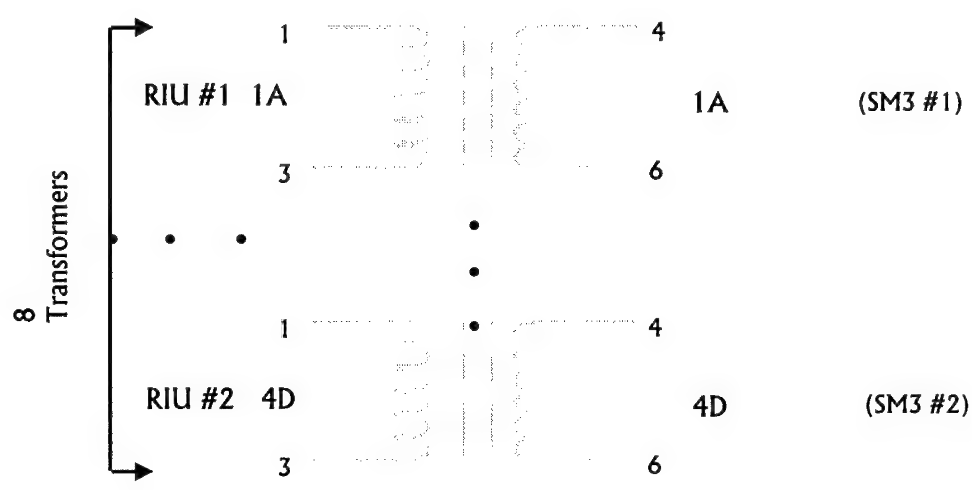
ISOLATION TRANSFORMERS SCHEMATIC FOR C2V#2



Notes: All 1:1 Isolation Transformers (audio Transformers) in this diagram were made by MagneTek (TRIAD TY-304P model). Center taps were not used.

Figure 13 Isolation Transformers Schematic for C2V #2

ISOLATION TRANSFORMERS SCHEMATIC FOR C2V#3



Notes: All 1:1 Isolation Transformers (audio Transformers) in this diagram were made by MagneTek (TRIAD TY-304P model). Center taps were not used.

Figure 14 Isolation Transformers Schematic for C2V #3

TOC Re-Engineering CEP

3-D Sound Separation in C2V_3

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Channel Assignment to RIU Ports

Highway	Radio Channel	RUI	RIU Port	Operator/CAU#
1	1,3,4,int	1	1	1
2	2,3,5, int	1	2	1
3	1,3,4,int	1	3	2
4	2,3,5, int	1	4	2
5	1,3,4,int	2	1	3
6	2,3,5, int	2	2	3
7	1,3,4,int	2	3	4
8	2,3,5, int	2	4	4

Figure 15 TOC Re-Engineering CEP 3-D Sound Separation in C2V #3

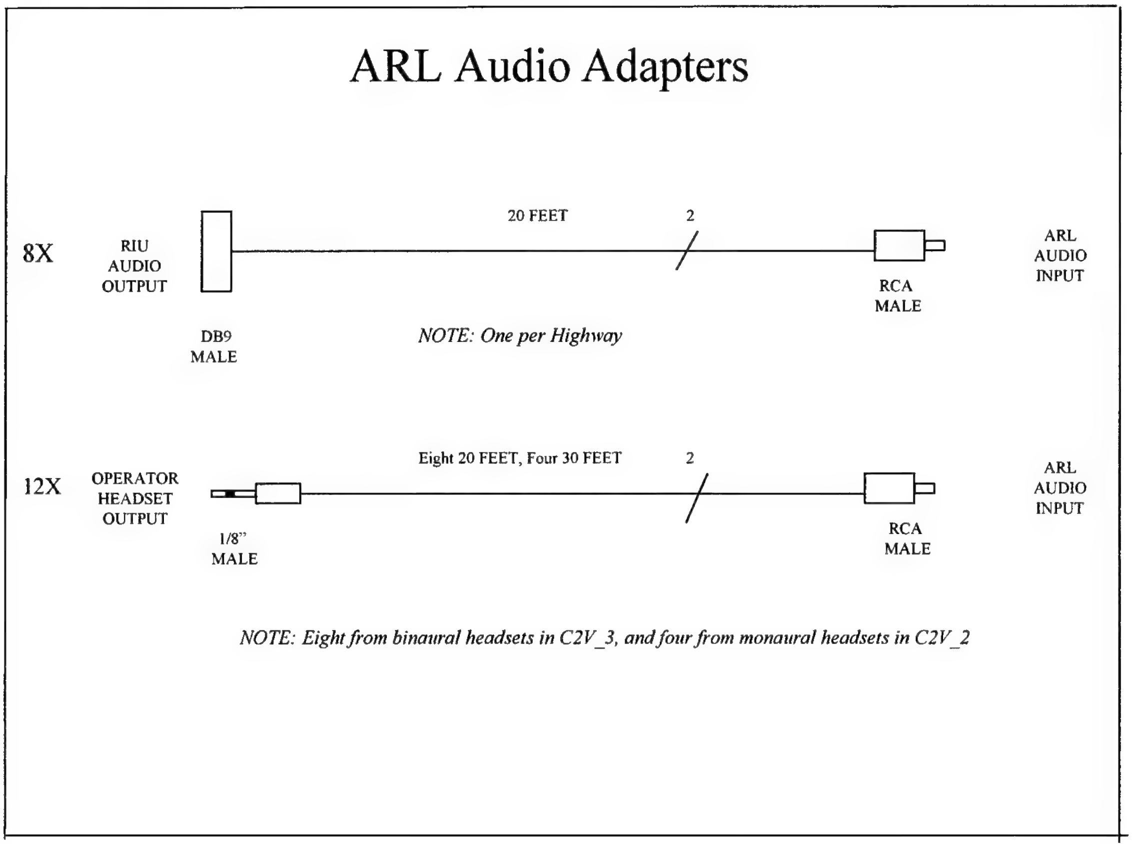


Figure 16 ARL Audio Adapters

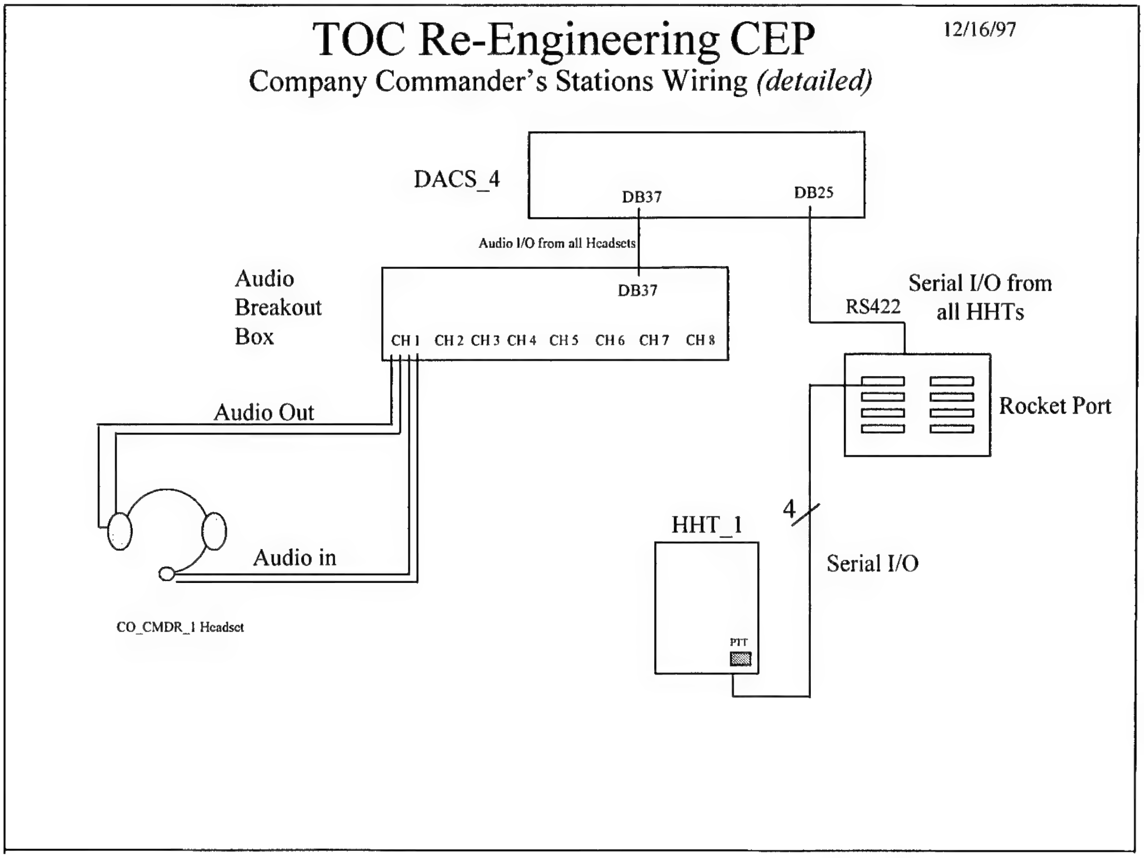


Figure 17 TOC Re-Engineering CEP Company Commander's Stations Wiring

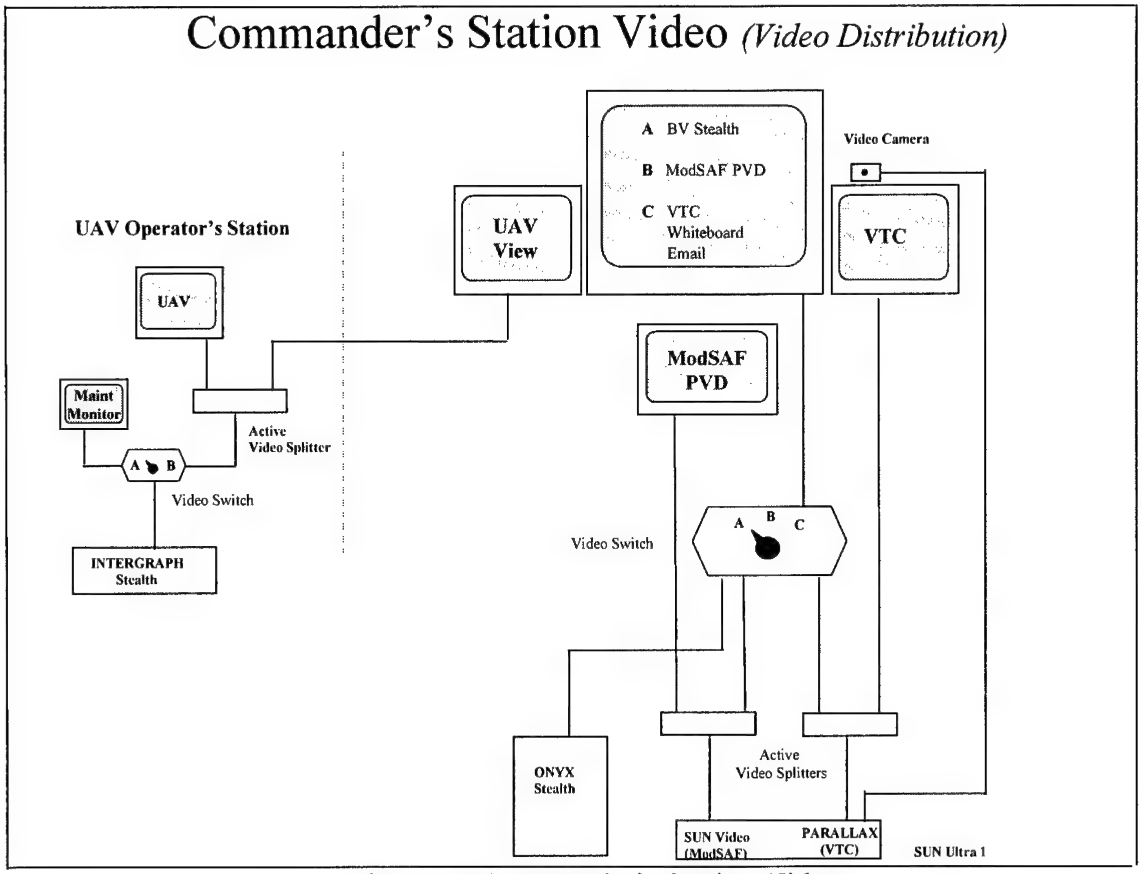


Figure 18 Commander's Station Video

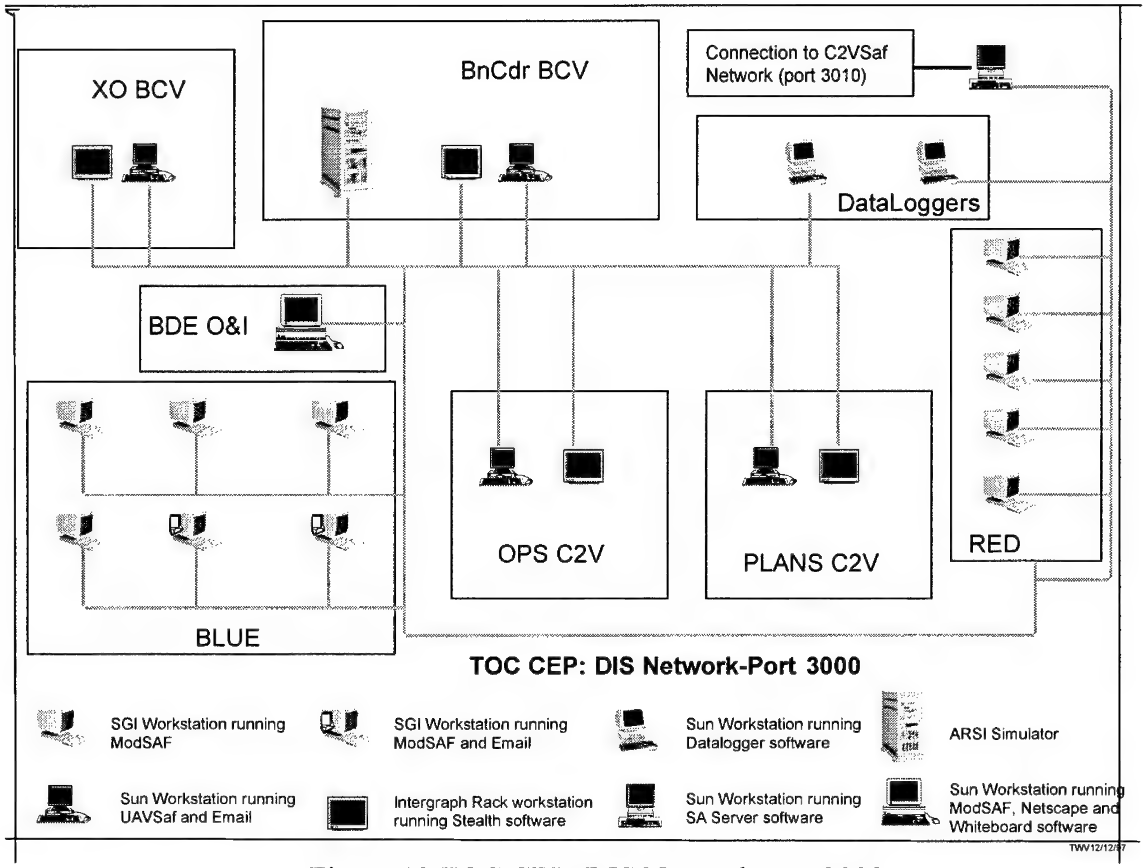


Figure 19 TOC CEP: DIS Network port 3000

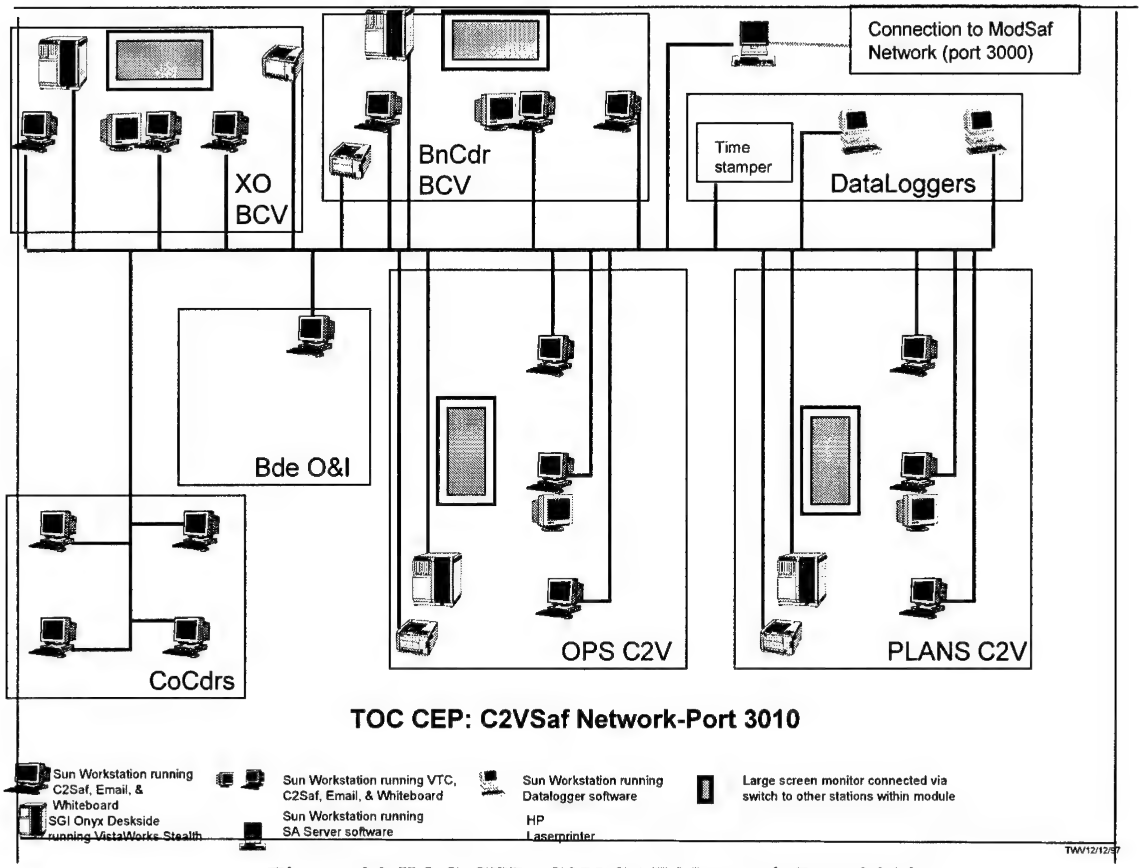


Figure 20 TOC CEP: C2V SAF Network Port 3010

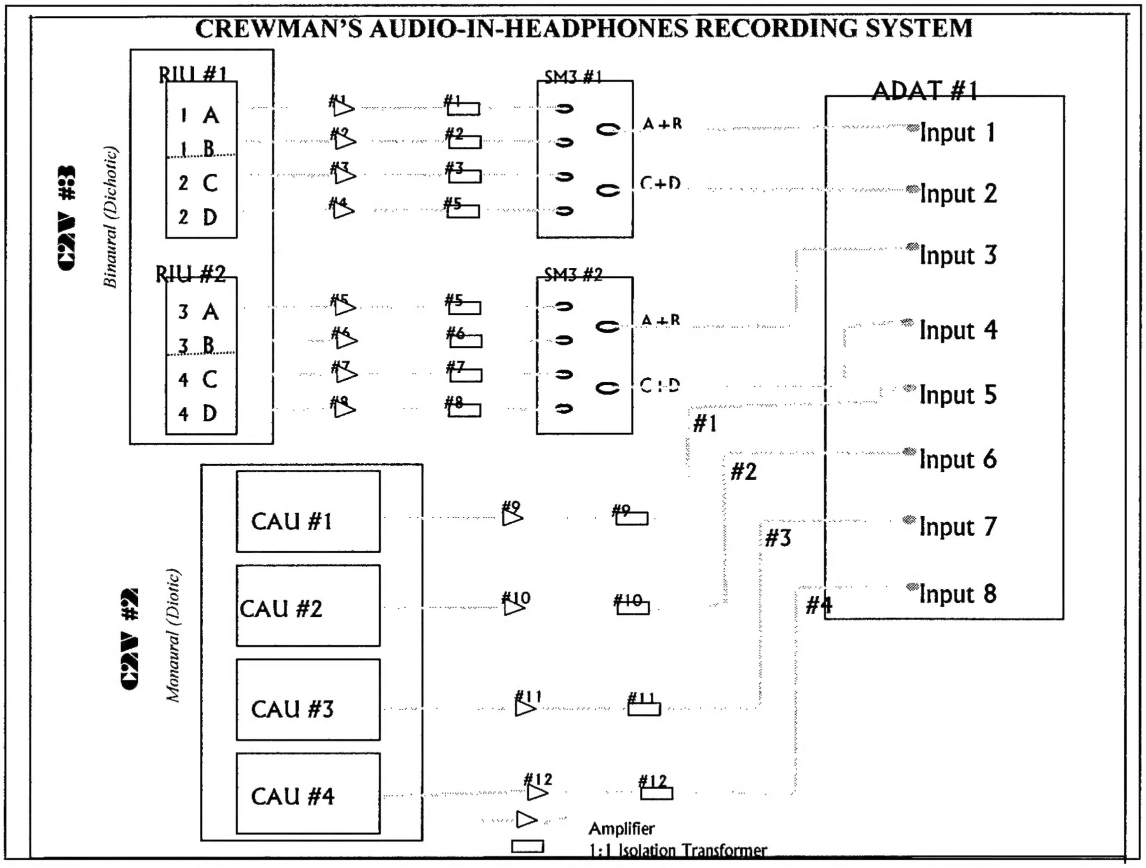


Figure 21 Crewman's Audio-in-Headphones Recording System

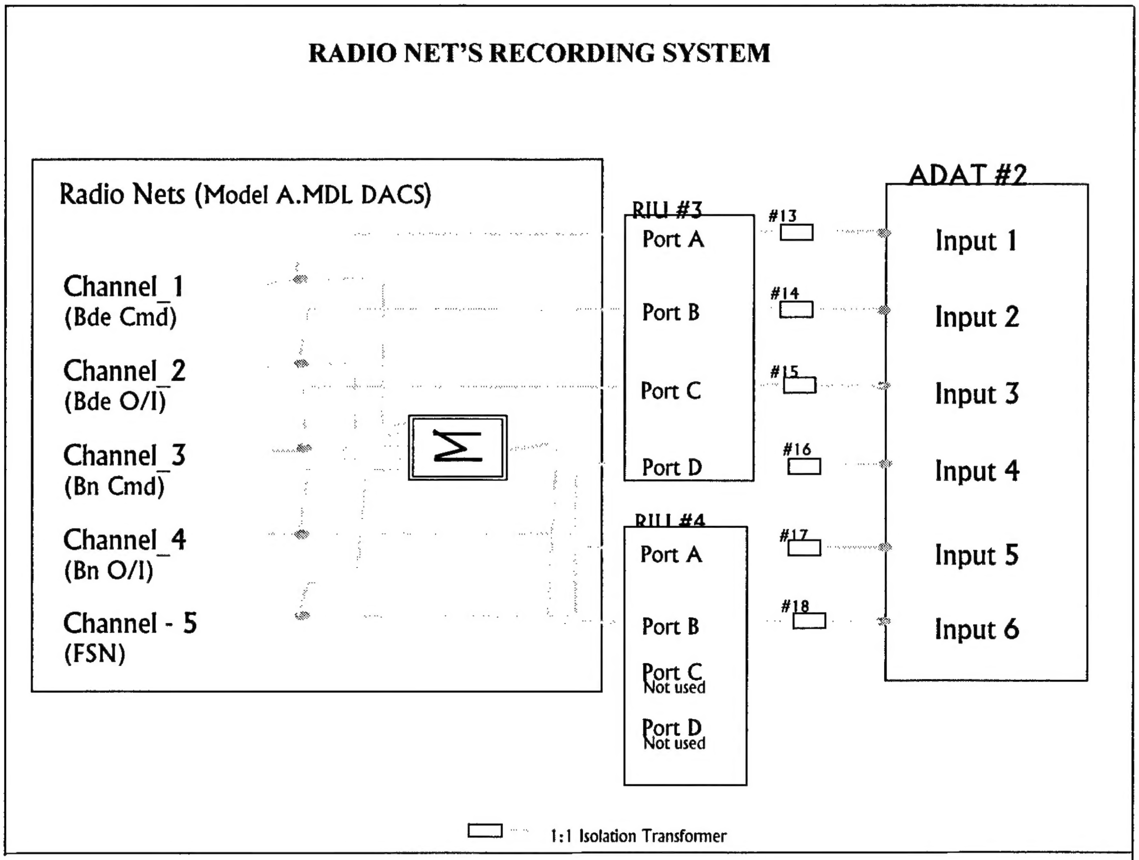


Figure 22 Radio Nets Recording System

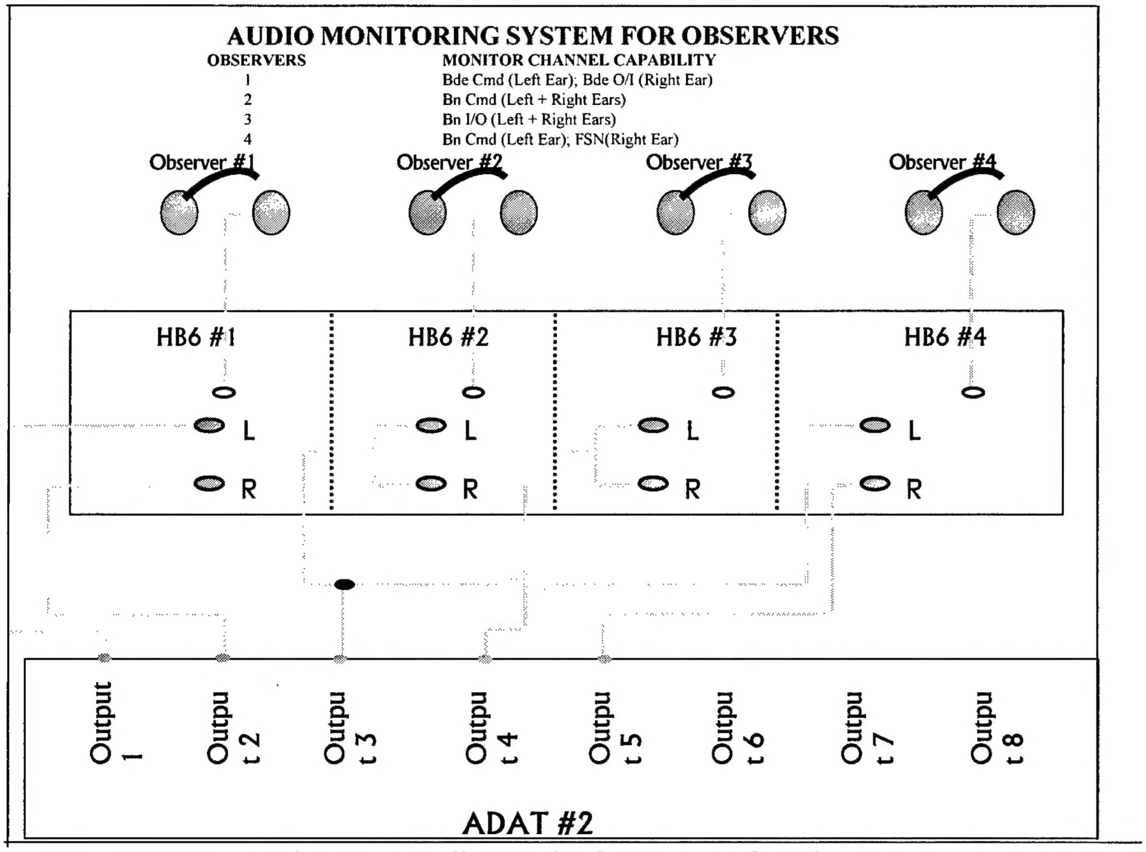
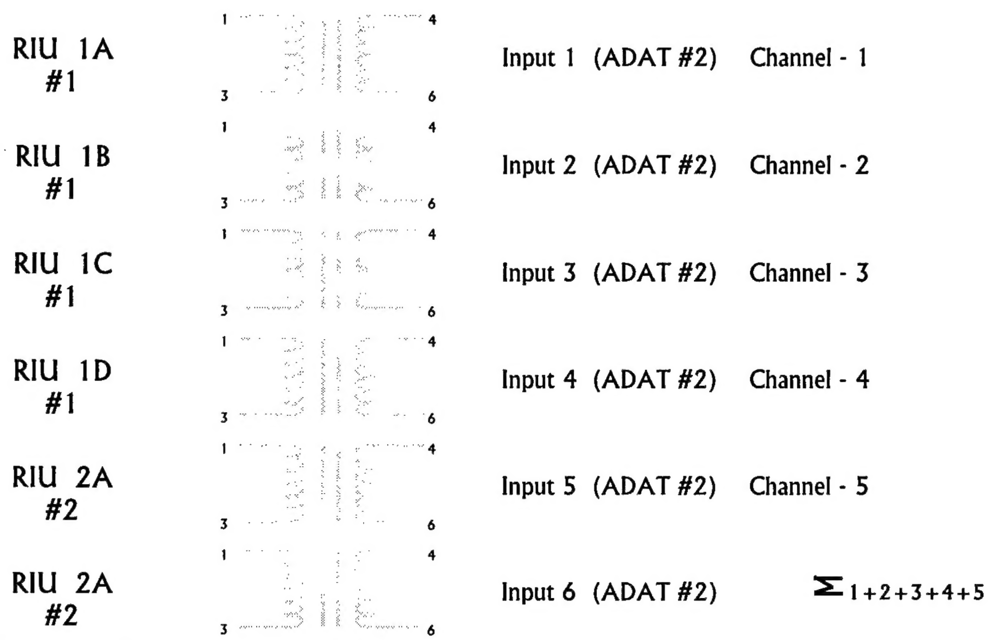


Figure 23 Audio Monitoring System for Observers

**ISOLATION TRANSFORMERS SCHEMATIC
FOR RADIO NETS**



Notes: All 1:1 Isolation Transformers (audio Transformers) in this diagram were made by MagneTek (TRIAD TY-304P model). Center taps were not used.

Figure 24 Isolation Transformers Schematic for Radio Nets